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(54) **[Title of the Invention]** Silicon Wafer Intrinsic Gettering Method

(57) Summary

[Goal] The goals of this invention are to obtain the desired gettering effect during heat treatment below 1000 °C and to make possible variation of the denuded zone thickness over an arbitrary thickness range.

[Content of the Invention] During intrinsic gettering heat treatment of a silicon wafer, the oxide-precipitate-containing silicon wafer is rapidly heated to 800 - 1000 °C, then maintained at this temperature range for 0.5 to 20 minutes. After this processing step, the silicon wafer is cooled to room temperature. Then this cooled silicon wafer is heated from the 500 - 700 °C temperature range up to 800 - 1000 °C at a rate of 2 to 10 °C/minute. The silicon wafer is maintained at this temperature for 2 to 48 hours.

[Limits of the Patent Claims]

[Claim 1] This invention is a silicon wafer intrinsic gettering treatment method. This method is characterized by, during intrinsic gettering heat treatment of a silicon wafer, said treatment including a step during which the oxide precipitate containing silicon wafer is rapidly heated to 800 - 1000 °C, then maintained at this temperature range for 0.5 to 20 minutes.

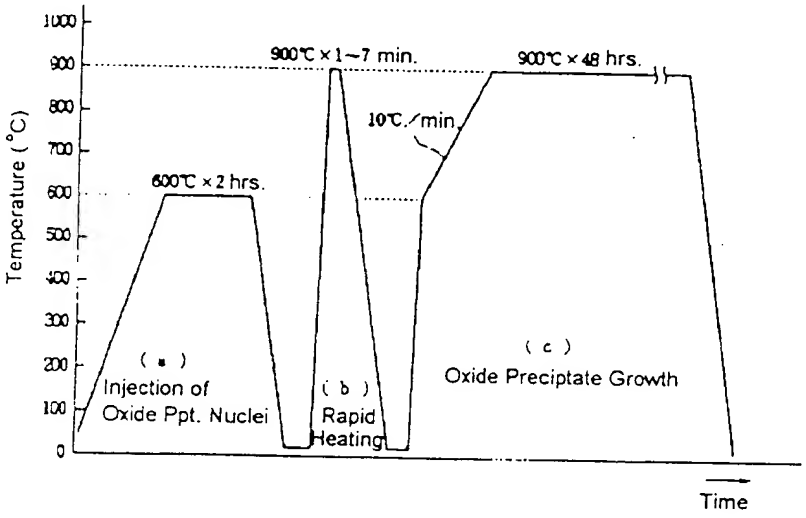
[Claim 2] This invention is a silicon wafer intrinsic gettering treatment method per Claim 1. The step during which the oxide precipitate containing silicon wafer is rapidly heated to 800 - 1000 °C is carried out by rapid loading the silicon wafer into a preheated furnace.

[Claim 3] This invention is a silicon wafer intrinsic gettering treatment method per

Claim 1. The step during which the oxide precipitate containing silicon wafer is rapidly heated to 800 - 1000 °C is carried out by use of a lamp-type furnace.

[Claim 4] This invention is a silicon wafer intrinsic gettering treatment method. The silicon ingot is sliced, and then the silicon wafer is ground and polished. Then rapid heat treatment of said oxide precipitate containing silicon wafer is immediately carried out by heating to 800 - 1000 °C, followed by maintenance in this temperature range for 0.5 to 20 minutes.

[Claim 5] This invention is a silicon wafer intrinsic gettering treatment method per any one of Claims 1 through 4. The silicon wafer, that had undergone rapid heating to 800 - 1000 °C, is then cooled to room temperature. Then this cooled silicon wafer is heated from the 500 - 700 °C temperature range up to the 800 - 1000 °C temperature range at a rate of 2 to 10 °C/minute. The silicon wafer is then maintained at this temperature for 2 to 48 hours.



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[TITLE]
The intrinsic gettering processing method of a silicon wafer
[SUMMARY]
[OBJECT]
There is a desired intrinsic gettering effect by the heat treatment 1000 degrees C or less. The die thickness of DZ layer is arbitrarily changeable again.
[SUMMARY OF THE INVENTION]
When a silicon wafer is heated and intrinsic gettering processing begins,
Rapid heating of the silicon wafer containing an oxygen deposition nucleus is carried out from a room temperature to 800 to 1000 degrees C, and the process which holds for 0.5 to 20 minutes is included.
The process which cools a silicon wafer to a room temperature further after this process.
And, it is desirable that the process which heats the cooled silicon wafer from 500 to 700 degrees C to 800 to 1100 degrees C at a 2 to 10 degree C /min rate, and holds for 2 to 48 hours at that temperature is included.
[CLAIMS]
[CLAIM 1]
A silicon wafer is heated and it relates to the intrinsic method which carries out gettering processing.
WHEREIN:
The process which carries out rapid heating of the silicon wafer containing an oxygen deposition nucleus, and holds it for 0.5 to 20 minutes from room temperature to 800 to 1000 degrees C is included.
The intrinsic gettering processing method of the silicon wafer which is characterised by the aforementioned.
[CLAIM 2]
The processing method of the claim 1 statement performed by putting quickly the silicon wafer which contains rapid heat an oxygen deposition nucleus into the furnace heated by 800 to 1000 degrees C from room temperature.
[CLAIM 3]
The processing method of the claim 1 statement performed by making 800 to 1000 degrees C heat quickly the silicon wafer which contains rapid heat an oxygen deposition nucleus, from room temperature by the lamp type high-speed heating furnace.
[CLAIM 4]
A silicon wafer is heated and it becomes as follows in the intrinsic method which carries out gettering processing. Process in which is cut from a silicon crystal rod, and holds the silicon wafer immediately after carrying out grinding polish for 0.5 to 20 hours at 500 to 800 degrees C, and introduces an oxygen deposition nucleus in the wafer,
The intrinsic gettering processing method of the silicon wafer which is characterised by the process which carries out rapid heating of the silicon wafer containing the oxygen deposition nucleus, and holds it for 0.5 to 20 minutes from a room temperature to 800 to 1000 degrees C being included.
[CLAIM 5]
The process which cools further the silicon wafer which carried out rapid heat and held for 0.5 to 20 minutes, to a room temperature,
The processing method in the statements of claim 1 or 4 containing the process which heats the cooled silicon wafer to 800 to 1100 degrees C at a 2 to 10 degree C/min rate, and holds it for 2 to 48 hours at that temperature from 500 to 700 degrees C.
[DETAILED DESCRIPTION OF INVENTION]
[0001]
[INDUSTRIAL APPLICATION]
This invention obtains the silicon wafer suitable for LSI production of DRAM etc.
For this reason, a silicon wafer is heated and it relates to the method which carries out intrinsic gettering processing.
[0002]
[PRIOR ART]

In recent years, based on mass production of mega-bit memory, high integration of a DRAM etc. semiconductor element is demanded.

The high-quality still more also about a silicon wafer is wanted.

There is an intrinsic gettering processing method as one method for responding to this desire.

This processing method makes a defect beforehand inside a silicon wafer, or adds the impurity intentional.

Contamination and the defect which are generated on the way of a subsequent process are absorbed on the defect made beforehand or the periphery of contamination.

It is the processing method which prevents that a defect and contamination generatation in the near field region on the surface of a wafer which makes a device.

[0003]

As shown, for example, in a figure 4, after this conventional gettering processing carries out annealing processing of the silicon wafer about 4 hours at 1150 degrees C, it is heat-treated about 16 hours at 700 degrees C.

Furthermore it is carried out by heat-treating about 4 hours at 950 degrees C.

Each of these 3 step heat treatments is performed in the nitrogen environment.

The remainder oxygen in a wafer is made to precipitate.

The oxygen in the depth of several micrometres is diffused and extinguished outside a wafer from the wafer surface by the heat treatment of the first stage.

After performing the nucleus formation for making the oxygen which was in the interior of a wafer by the heat treatment of a second stage precipitate,

SiO2 phase is made to precipitate by the heat treatment of a third stage.

The layer (denuded zone and a following DZ layer are called) by which a sludge is not formed in the wafer surface by this comes to be introduced. An internal oxygen sludge (intrinsic source of a gettering) generates in a subsequent process.

The gettering of the contaminated metal and the impurity which do a bad influence is carried out to the operation of a device, and it is made to fix it.

The defect in the near field region on the surface of the wafer and a generation of contamination which make a device are inhibited.

[0004] [PROBLEM ADDRESSED]

However, in the conventional intrinsic gettering processing method, outside diffusion of the oxygen which is in the depth of several micrometres from the wafer surface is carried out.

In order to form DZ layer in the wafer surface, the hot heat treatment exceeding 1000 degrees C is needed. It originates in this hot heat treatment, and curvature generates to a silicon wafer or it is become easy to contaminate a wafer.

Or there was fault from which the bad influence of the transposition called slip line in a wafer being generated tends to happen. A device is processed in lower temperatures by high integration of a device in recent years,

And, it associates with this low- temperature processing, which is strongly desired also in intrinsic gettering processing which is a pre-process.

[0005]

The objective of this invention is that the intrinsic gettering processing method of the silicon wafer which performs so the intrinsic gettering effect of the desire by the heat treatment 1000 degrees C or less is offered.

The other objective of this invention is that the intrinsic gettering processing method which can change the die thickness of DZ layer arbitrarily is offered.

[0006]

[SOLUTION OF THE INVENTION]

As shown in a figure 1, it is characterised by the processing method of this invention containing the process which carries out rapid heat of the silicon wafer which heats a silicon wafer, and is intrinsic improvement of a method which carries out gettering processing, and contains an oxygen precipitate nucleus, and holds it for 0.5 to 20 minutes from a room temperature to 800 to 1000 degrees C.

[0007]

Hereafter, this invention is explained in full detail. It cut from the silicon crystal rod which grew by the Czochralski method (called the CZ method in the following), and two or more part of the oxygen atom mixed during the crystal gather in the silicon wafer immediately after carry out grinding polish in a crystal, and an oxygen precipitate nucleus is formed.

Although the silicon wafer immediately after cutting and carrying out grinding polish from the silicon crystal rod as a silicon wafer containing an oxygen precipitate nucleus for this reason is sufficient,

Since the oxygen precipitate nucleus is introduced into relatively high density among wafers, that which held this silicon wafer for 0.5 to 20 hours at 500 to 800-degree C relatively low temperature is desirable.

Moreover, although the method of rapid heating have the desirable method which put quickly the silicon

wafer containing the oxygen precipitate nucleus of a room temperature state into the furnace heated by 800 to 1000 degrees C, it arrange in the high-speed heating furnace which used the lamp which can generate in high temperature the silicon wafer containing the oxygen precipitate nucleus of a room temperature state.

The method turn on a lamp switch, carry out the starting of the heat emission, and make 800 to 1000 degrees C heat quickly is sufficient.

Since a wafer can be uniformly heated when carrying out rapid heating by lamp light irradiation, there is an advantage that a wafer more seldom curves as compared with the case where it puts into the furnace heated beforehand.

Rapid heating is carried out, and at less than 800 degrees C, the silicon atom between lattices seldom becomes a shortage state within a wafer, and, as for the reaching final temperature, an oxygen precipitate nucleus seldom grows within a wafer.

Moreover if 1000 degrees C is exceeded, the same trouble as a conventional processing method will generate.

Preferably, it is 850 to 950 degrees C. Also, holding time on the wafer surface is less than 0.5 minutes,

And, the diffusion time toward the inner part of the wafer of the silicon atom between lattices is too short.

Disappearance of an oxygen precipitate nucleus near the wafer surface is inadequate, and DZ layer cannot fully be assured.

Moreover if 20 minutes are exceeded, since DZ layer of the die thickness more than required will be obtained in the first place, it becomes as follows.

Moreover since the oxygen sludge which has already grown ceases to disappear even when an oxygen precipitate nucleus grows during a second maintenance, it becomes a stable size and the silicon atom between lattices is diffused after that in this case, a holding time is decided in 0.5 to 20 minutes.

Preferably, it is 1 to 7 minutes. Rapid heating is performed in the nitrogen environment, the oxygen environment, or atmospheric air. Preferably, it is among the nitrogen environment.

[0008]

A silicon wafer is cooled to a room temperature after this rapid heating.

It is desirable to heat this cooled silicon wafer to 800 to 1100 degrees C at a 2 to 10 degree C/min rate, and to hold it for 2 to 48 hours at that temperature from 500 to 700 degrees C.

This is for stabilizing and growing the surviving oxygen precipitate nucleus, without disappearing within a wafer.

The temperature rise rate and the heat temperature after cooling are established as the range for the objective which prevents the shortage state of the silicon atom between lattices.

The heating at the time of a cool and after cooling is performed in the same environment as the rapid heating.

[0009] [Effect]

Generally, within a wafer, the density of the silicon atom between lattices is lower than heat equilibrium density, and when the silicon atom between lattices is in a shortage state, an oxygen precipitate nucleus becomes easy to grow stably.

When the density of the silicon atom between lattices is not lower than heat equilibrium density (i.e., when there is nothing in the shortage state), an oxygen precipitate nucleus is in the tendency that would disappear or that growth becomes unstable.

If rapid heating of the attainment temperature is carried out the silicon wafer which contains an oxygen precipitate nucleus by the characteristic process of this invention, from the room temperature to 800 to 1000 degrees C,

Of course and the interior of a wafer also become below heat equilibrium density temporarily, the silicon atom between lattices becomes a shortage state, and, as for the wafer surface, an oxygen precipitate nucleus becomes a stable growth environment.

Since this silicon atom between lattices that lacked is compensated simultaneously and it becomes a stable state, it is begun inside a wafer formation of the silicon atom between lattices to happen and to diffuse the formed silicon atom between lattices on the wafer surface.

Near the wafer surface in the shortage state of the silicon atom between lattices becomes a saturation state immediately by formation of the silicon atom between lattices, and an oxygen precipitate nucleus begins disappearance.

However, in order to require a certain amount of time to diffuse even inside a wafer the silicon atom between lattices formed on the wafer surface, it becomes as follows. A stable growth environment continues for the oxygen precipitate nucleus for a long time so that it goes into the interior of the wafer surface deeply.

Therefore, the die thickness of the area (DZ layer) in which an oxygen precipitate nucleus, i.e., defect, is not formed is grown so that the consistency of an oxygen precipitate nucleus is so low that it is close to the wafer surface and this heat treating time (0.5 to 20 minutes) is long.

Moreover the diffusion coefficient of the silicon atom between lattices is so large that temperature is high in

800 to 1000 degrees C, and the die thickness of DZ layer is grown for a short time. If it heats again to 800 to 1100 degrees C after carrying out rapid heating and cooling to a room temperature,
The oxygen precipitate nucleus inside the wafer survived by rapid heating grows, and it becomes an oxygen sludge. And, it becomes the stable intrinsic source of a gettering.
[0010] [Embodiment]
Next, the embodiment of this invention is demonstrated in detail based on a drawing.
(a)
From the silicon single crystal rod which was able to be pulled up by the provision CZ method of a sample, it cuts, and it was prepared 7 sheets, having used the silicon wafer of the following characteristic to the extent that grinding polish was carried out as the sample.
Diameter: 5 inches
Surface bearing: <100>
Conducted type: P-type (the boron as a dopant is added)
Resistance factor: Appx. 10 OHM/cm
Die thickness: Appx. 620 microns
Oxygen concentration:1.3 to 1.4x1017/cm3 between initial lattices
(Old ASTM) Initial carbon density: 1.0x1016/cm3
(Old ASTM) Following
(b)
First stage heat treating (introduction of an oxygen precipitate nucleus)
As shown in a figure 1 (a), the sample of 7 sheets was put into the heat-treat furnace heated by 600 degrees C, and it heat-treated for t 1= 2 hours in the nitrogen environment.
The oxygen deposition nucleus was introduced in the wafer by this comparatively low hot-temperature processing.
The sample of 7 sheets was taken out from the furnace and it cooled to the room temperature.
[0011]
(c)
Second stage heat treating (rapid heating)
Subsequently, as shown in a figure 1 (b), the sample of 6 sheets is quickly inserted in the heat-treat furnace heated by 900 degrees C.
Respectively t2= 1 minute, 2 minutes, 3 minutes, 4 minutes, 5 minutes, and 7 minutes were held.
The sample heat-treated in 6 kinds of time was quickly taken out from the furnace, and it cooled to the room temperature.
Only the oxygen precipitate nucleus of the surface near field region of a wafer was extinguished by this rapid heat, and the oxygen precipitate nucleus was made to remain inside a wafer.
[0012]
(d)
Third stage heat treating (growth of an oxygen precipitate nucleus)
Then, after inserting the sample of 6 sheets in the heat-treat furnace heated by 600 degrees C quickly from a room temperature, as shown in a figure 1 (c),
The temperature rise was carried out at the nearly 10 degree C/min rate, it maintained for t3=48 hours in the place given to 900 degrees C, subsequently, the sample of 6 sheets was taken out from the furnace, and it cooled to the room temperature.
[0013]
(e)
It becomes as follows by the observation by the optical microscope. The opening of the sample of 1 sheet only of a first stage heat treatment and the sample of 6 sheets which carried out third stage heat treating is carried out, respectively.
After processing that opening surface with etching liquid (light etching liquid) which has a selectivity to an oxygen sludge, it observed under the optical microscope.
That result is shown in a figure 2.
The small white spot of a large number shown in a figure 2 is an oxygen sludge.
With the sample for t2= 0 minute (i.e., first stage heat treatment), it becomes as follows from the wafer surface so that clearly from a figure 2. Among those it applies to a part and the oxygen precipitate nucleus was introduced uniformly.
Moreover t2 becomes as follows increasing in 7 minutes from 1 minute. In the wafer surface, it became clear that the area which the oxygen precipitate nucleus disappeared, i.e., DZ layer, increases.
It is t2= 1 minute and DZ layer is appx. 20 microns.
DZ layer was appx. 150 microns in t2= 7 minutes.
[0014]
(f)

About the sample of seven measurements of an oxygen sludge consistency, the consistency of the oxygen sludge which it is as a result of an oxygen deposition nucleus's growing was measured.
That is, the number of the oxygen sludge per unit volume applied to the core of a wafer from the wafer surface about an each sample is computed.

The situation of having been distributed in the depth direction of a wafer was investigated.

That result is shown in a figure 3. It becomes as follows like the microphotography figure of a figure 3 to the figure 2.

t2 becomes as follows from 1 minute according to increasing in 7 minutes. On the surface of a wafer, an oxygen precipitate nucleus disappears gradually.

It became clear that DZ layer increases.

[0015]

[EFFECT OF THE INVENTION]

To the aforementioned, the formation of the conventional intrinsic source of a gettering needs the elevated temperature heat treatment exceeding 1000 degrees C.

Curvature generates to a silicon wafer.

Moreover, it is become easy to contaminate a wafer.

Or the thing with the fault from which the bad influence of the transposition called slip line in a wafer being generated tends to happen becomes as follows by according to this invention giving a heat treatment 1000 degrees C or less to a silicon wafer.

There can be a desired intrinsic gettering effect.

It can fully correspond to low temperature processing of device formation temperature in recent years.

Moreover since DZ layer can be formed by the heat treatment of the comparatively short time of several minutes, there is also an advantage raised in the productive efficiency of a product.

Furthermore it becomes as follows by changing the maintenance temperature and the holding time in rapid heating.

The die thickness of DZ layer is also arbitrarily changeable.

[BRIEF EXPLANATION OF DRAWINGS]

[FIGURE 1]

The figure showing the temperature of the intrinsic gettering heat treatment of this invention embodiment, and the relationship of time.

[FIGURE 2]

The electron microscope photpgraphy figure of a crystal configuration in the opening surface of the silicon wafer of this invention embodiment.

[FIGURE 3]

The figure showing the distribution situation of the oxygen sludge in the opening surface of the silicon wafer of this invention embodiment.

[FIGURE 4]

The figure showing the temperature of the intrinsic gettering heat treatment of the former corresponding to a figure 1, and the relationship of time.